Isothermal precipitation of Widmanstätten ferrite on a Fe-3.1 Pct Ni-0.1 Pct C steel

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Purpose and scope

An investigation on the mechanism of ferrite Widmastätten sideplate growth is currently being conducted on a Fe-3.1 Pct Ni - 0.1 Pct C steel.

The isothermal formation of proeutectoid Widmanstätten ferrite at 620 °C, starting from two different microstructures, was studied by metallographic analysis. Both structures were used as starting microstructures: a fully austenitic one and an austenite plus allotriomorphic ferrite one.

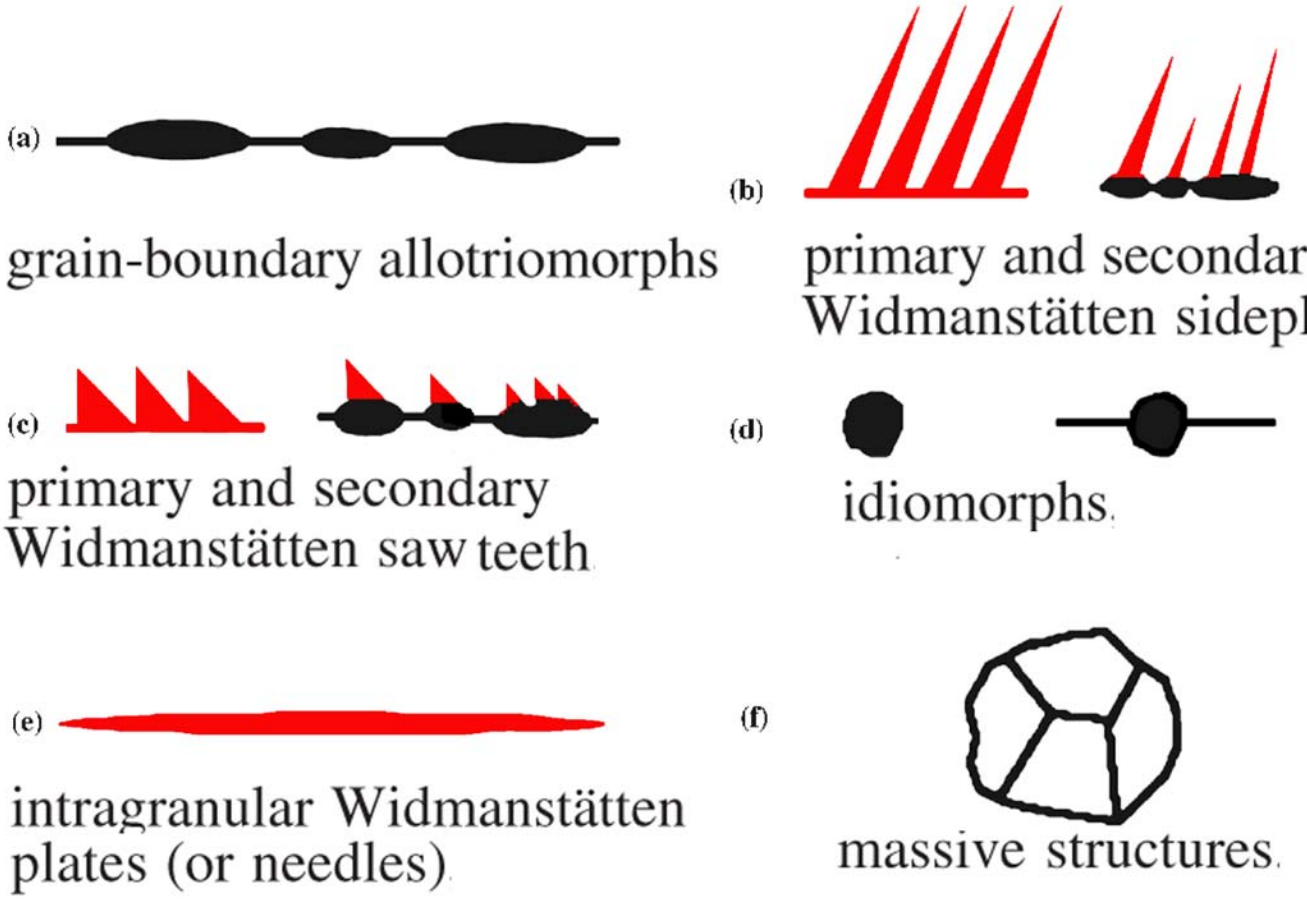
Salt bath heat treatments were carried out and the heat treated samples then analyzed by optical microscopy.

Purpose and scope

The initial results of an on-going work are present.

Current experimental drawbacks are discussed.

The role of propagation of local instabilities and/or sympathetic nucleation on secondary sideplate nucleation and growth is discussed.



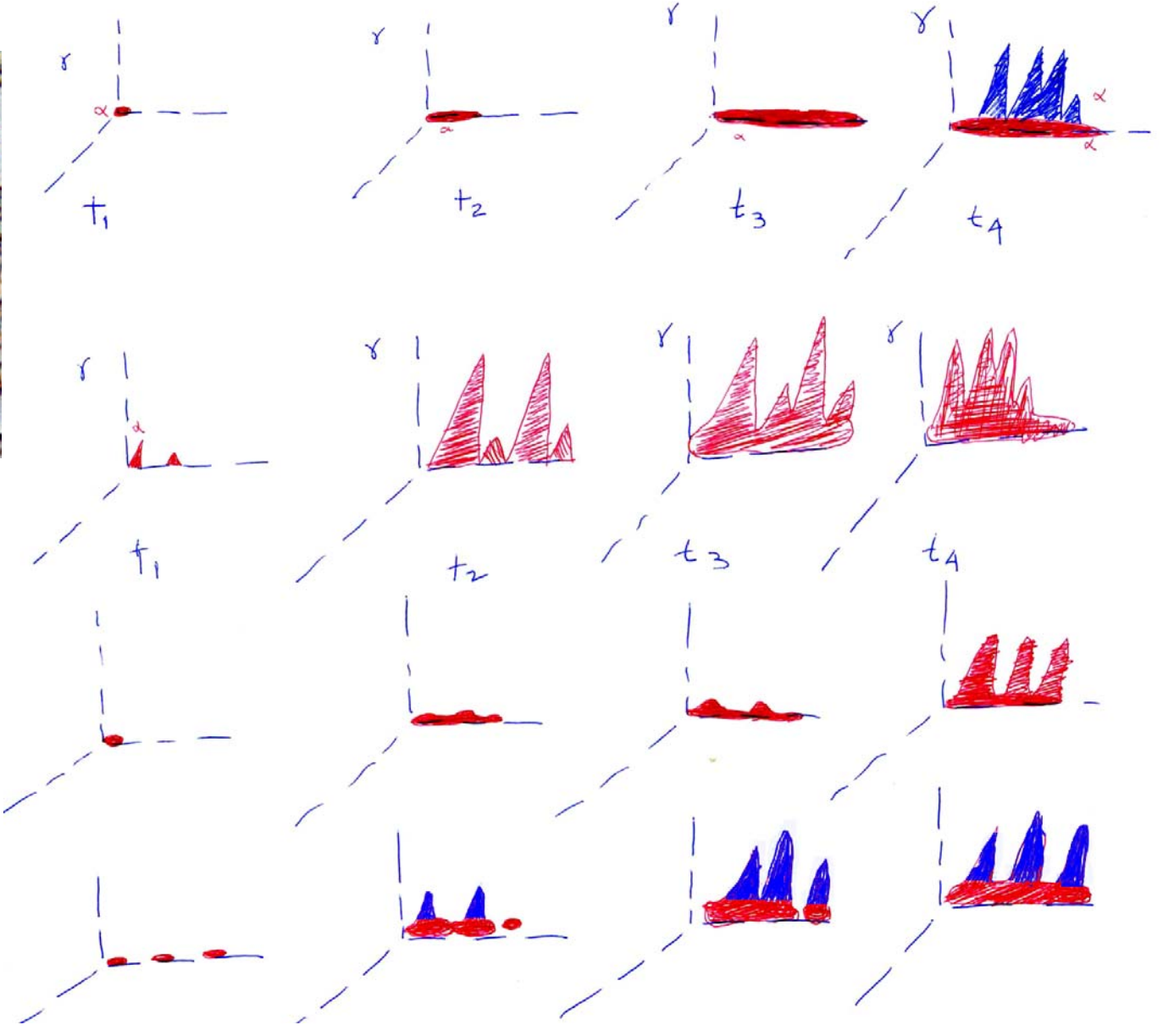
Dubé morphological classification system,[9,18]
as modified by Aaronson:[10]

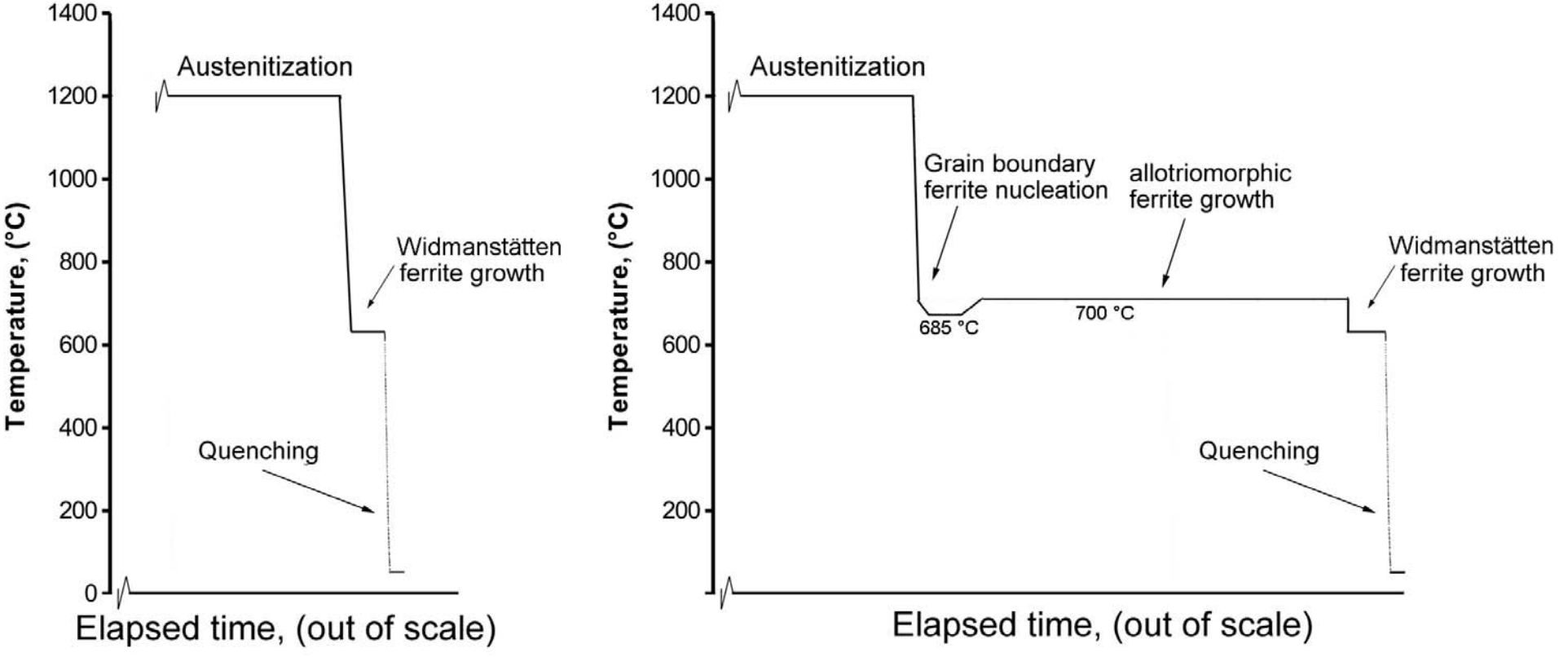
After, M.V. KRAL and G. SPANOS Met. Mat. Trans.-A, 36A (2005) 1199-1207

9. C.A. Dubé, H.I. Aaronson, and R.F. Mehl: Rev. Metall., 1958, vol. 55 (3), pp. 201-10.
10. The Decomposition of Austenite by Diffusional Processes, H.I. Aaronson, ed., Interscience, New York, NY, 1962.
18. C.A. Dubé: Ph.D. Dissertation, Carnegie-Mellon University, Pittsburgh, PA, 1948.

Microscope observation

Mechanism ???





Thermal cycles for inducing Widmanstätten ferrite growth in
(i) a fully austenitic microstructure, and
(ii) an austenite plus allotriomorphic ferrite microstructure.

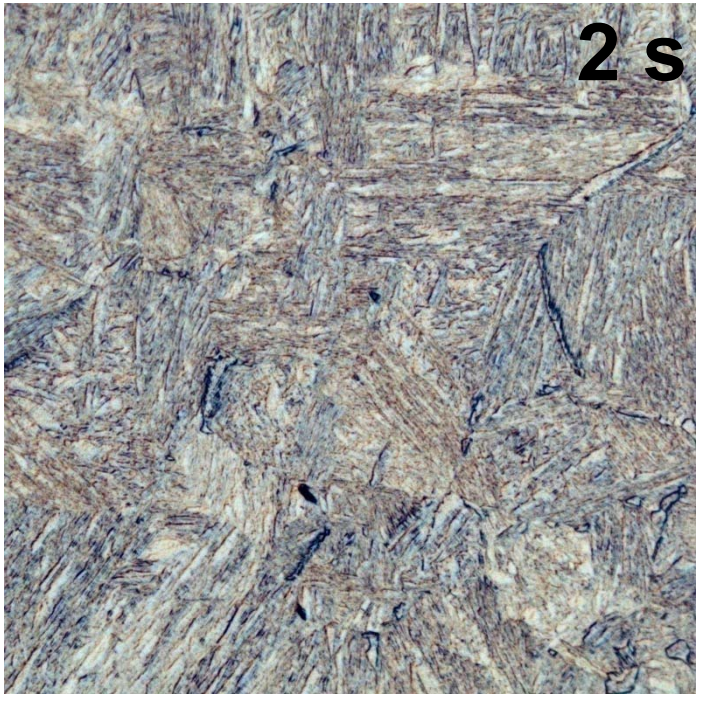
SALT BATH HEAT TREATMENTS

A time delay between the end of austenitization and the start of the isothermal hold was unavoidable.

A time delay between the end of the isothermal hold (620 °C) and the water quenching was unavoidable.

(A) carbolite tubular furnace (B) clamp used to break glass capsule before salt bath treatment (C) barium chloride salt bath (D) water quenching bucket.

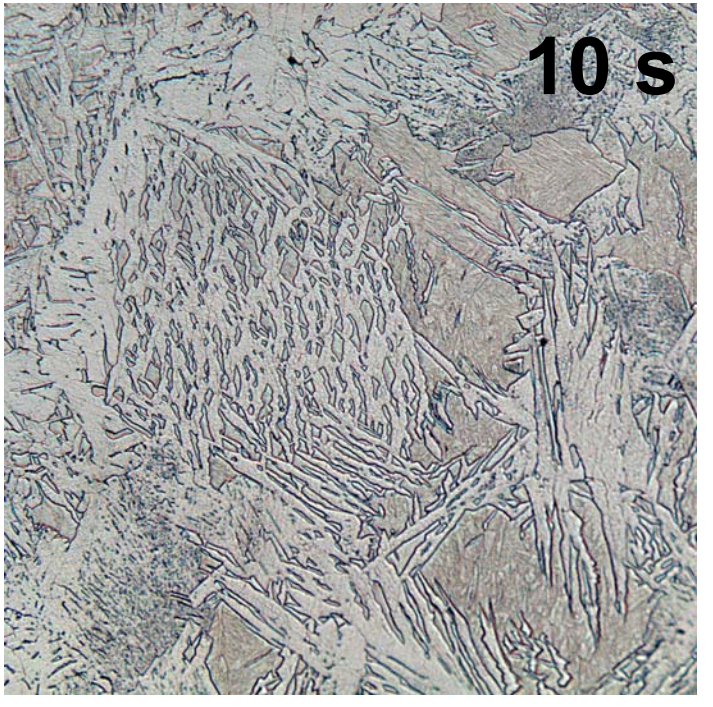
After **WEMEKAMP**, Mark, Widmanstätten Precipitate in Fe-C-Ni Alloys. Internal SIMaP report (unnumbered) 2008.



Thermal cycles for inducing Widmanstätten ferrite growth in a fully austenitic microstructure:

1200 °C (18 h)
→ 620 ° C

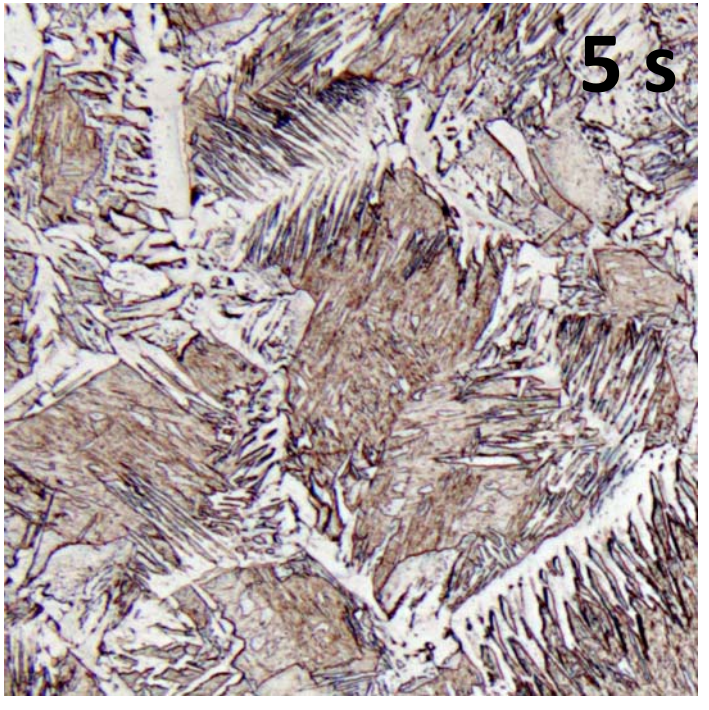
100 μm

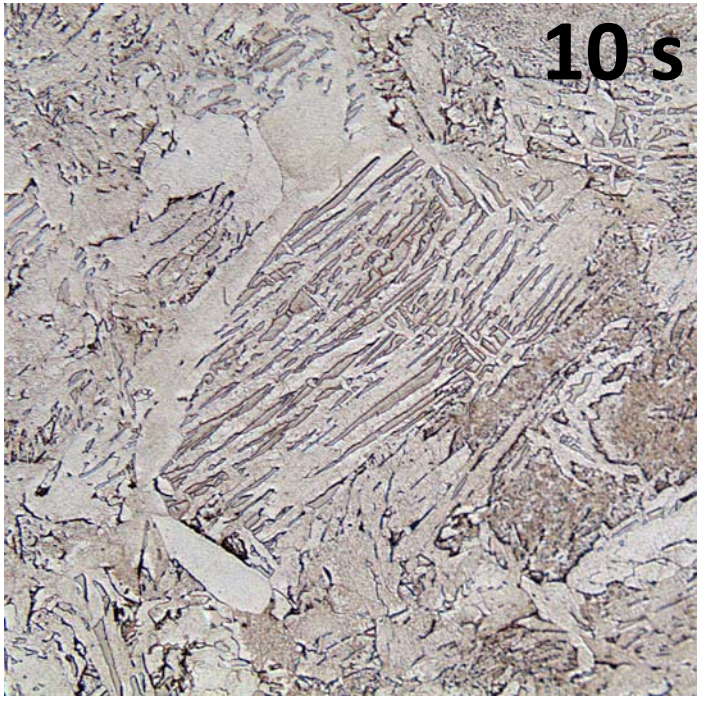


Thermal cycles for inducing Widmanstätten ferrite growth in an austenite plus allotriomorphic ferrite microstructure:

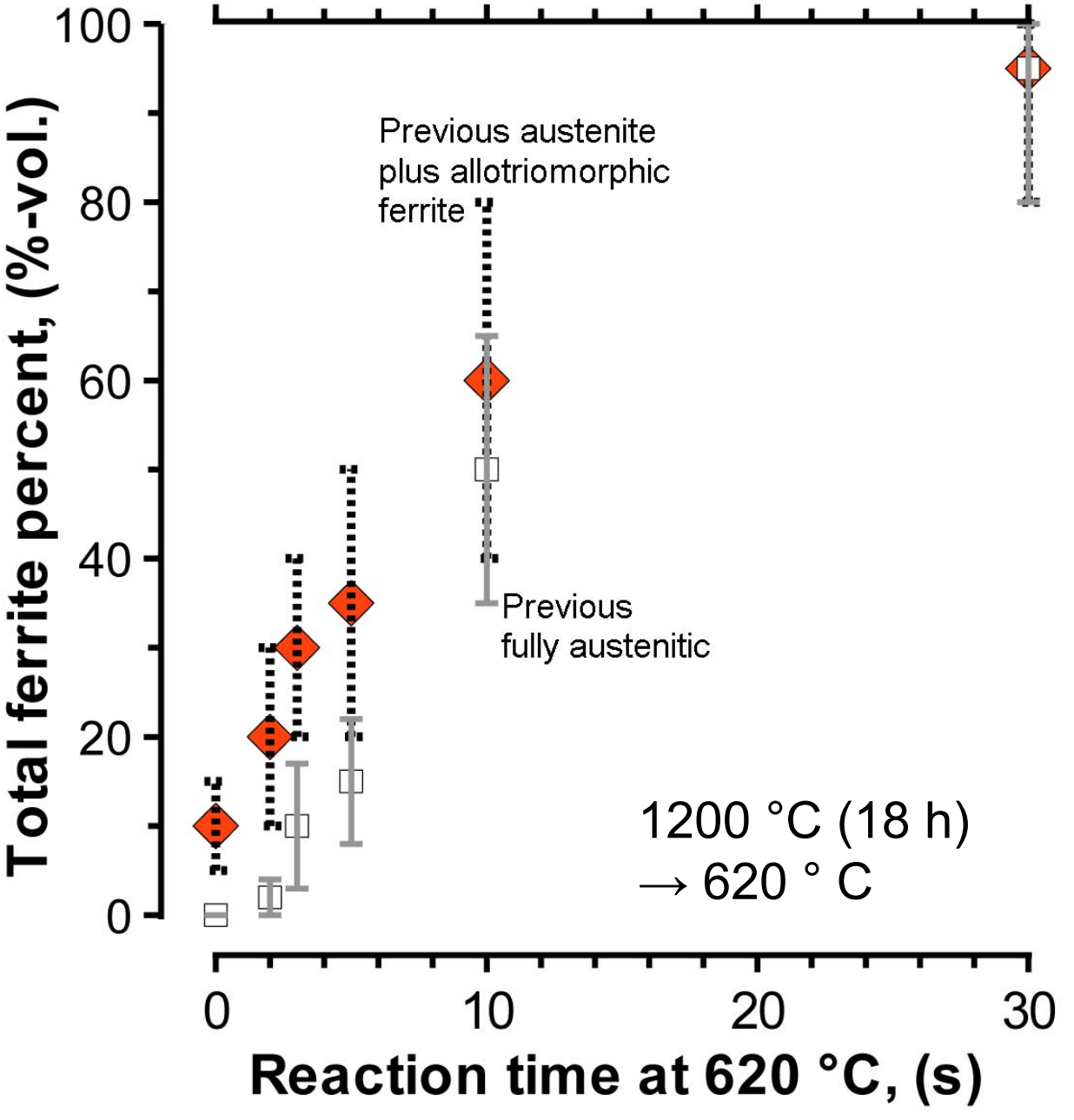
1200 °C (18 h)
→ 700 ° C (1 h)
→ 620 ° C

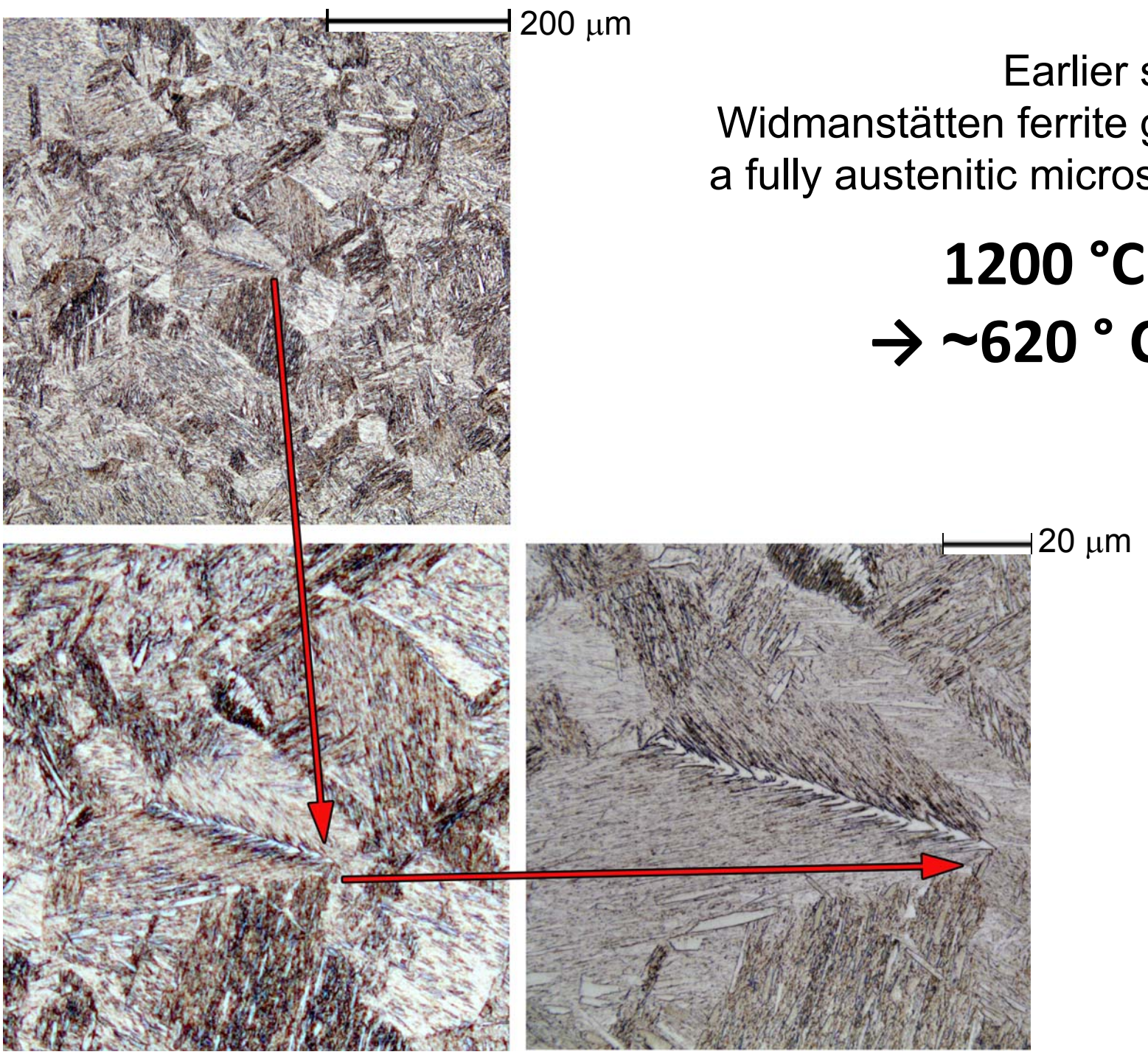
100 μm





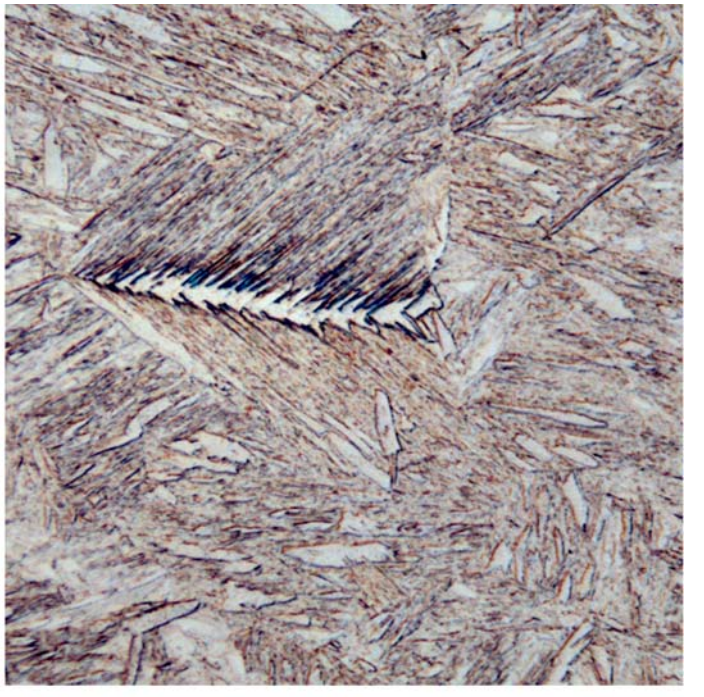
Due to experimental drawbacks as well as the nature itself of the reaction, large scatter on the total ferrite percent determination has been obtained

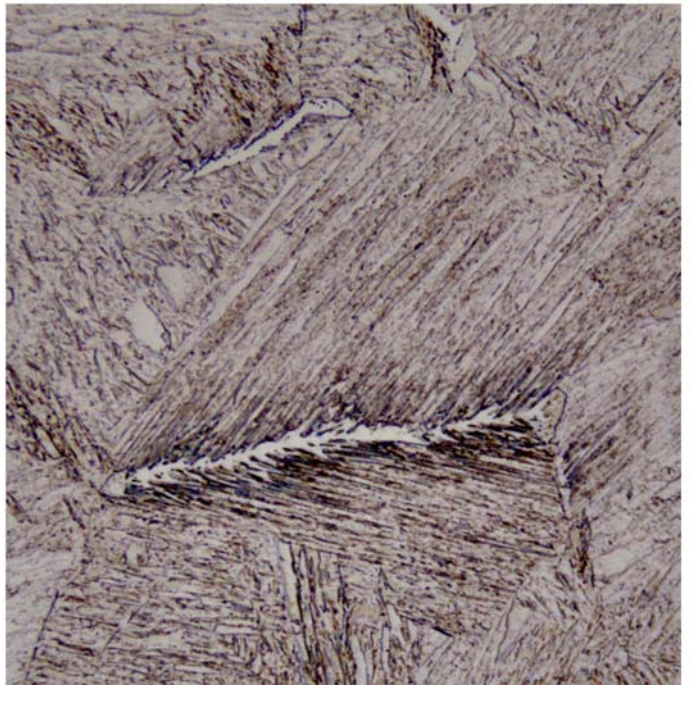




Earlier stages of
Widmanstätten ferrite growth in
a fully austenitic microstructure:

1200 °C (18 h)
→ ~620 ° C (~1s)



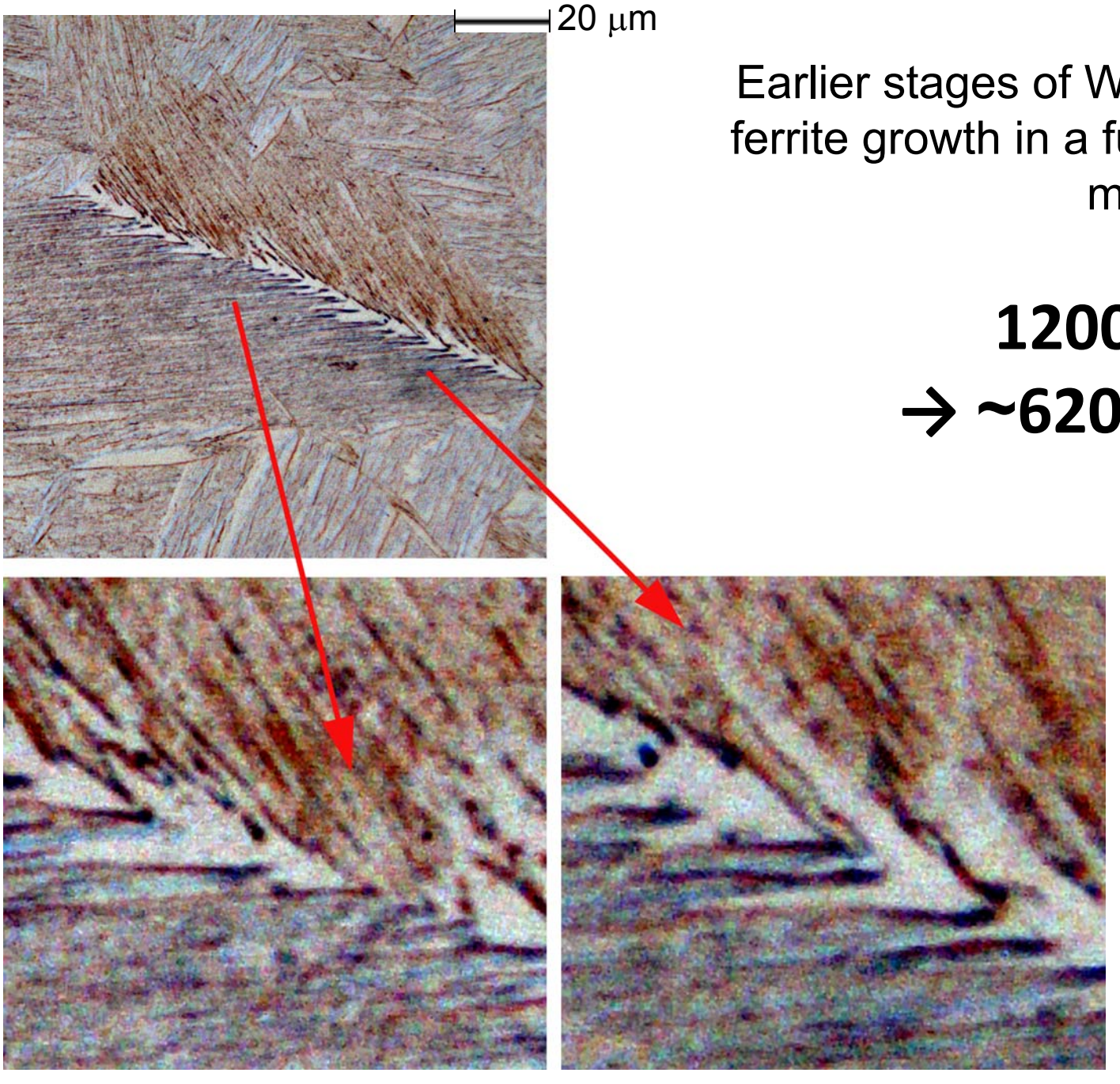


20 μm

Earlier stages of Widmanstätten ferrite growth in a fully austenitic microstructure:

1200 °C (18 h)

→ ~620 ° C (~1s)

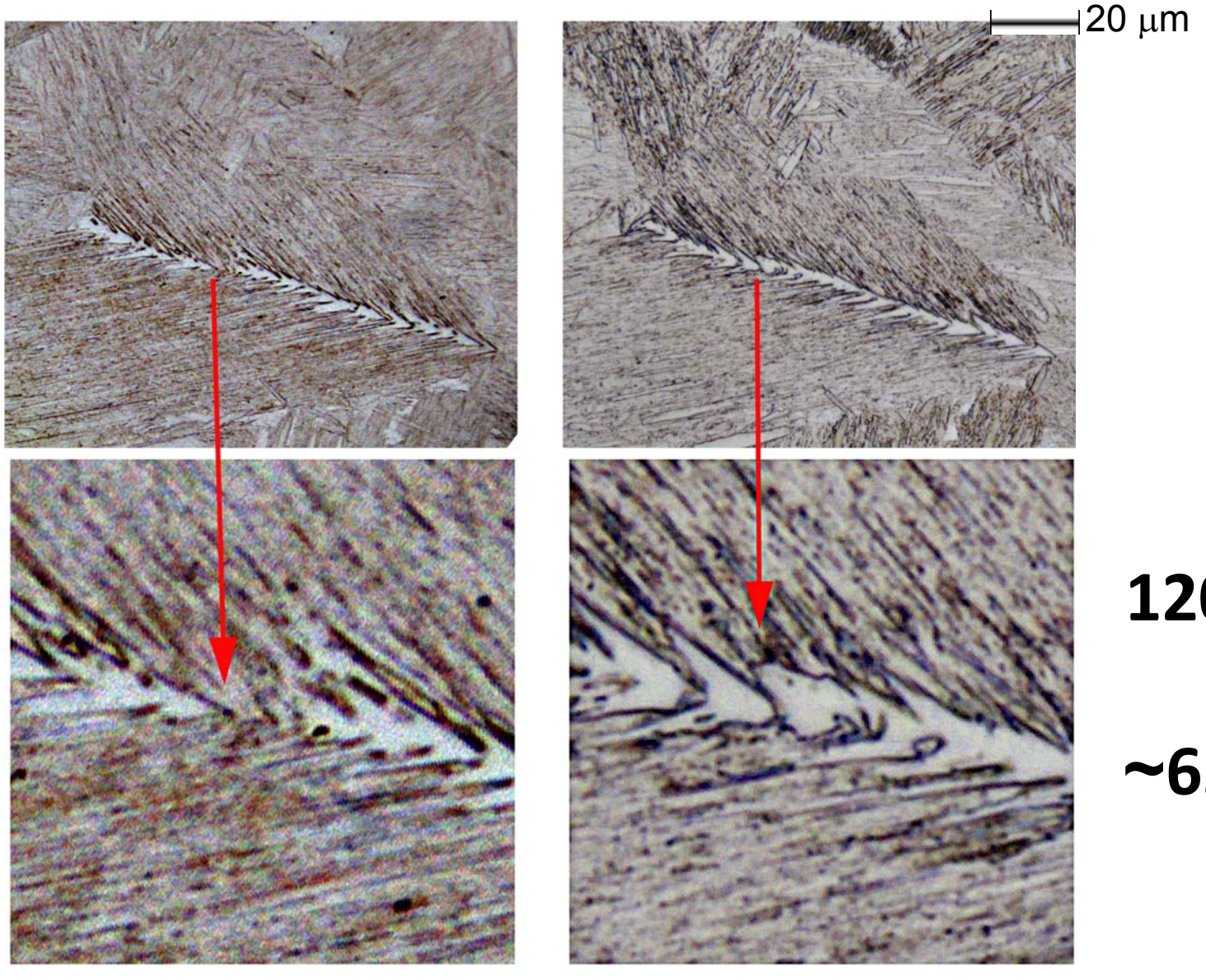


Earlier stages of Widmanstätten ferrite growth in a fully austenitic microstructure:

1200 °C (18 h)
→ ~620 ° C (~1s)

First polishing + etching

Second polishing + etching

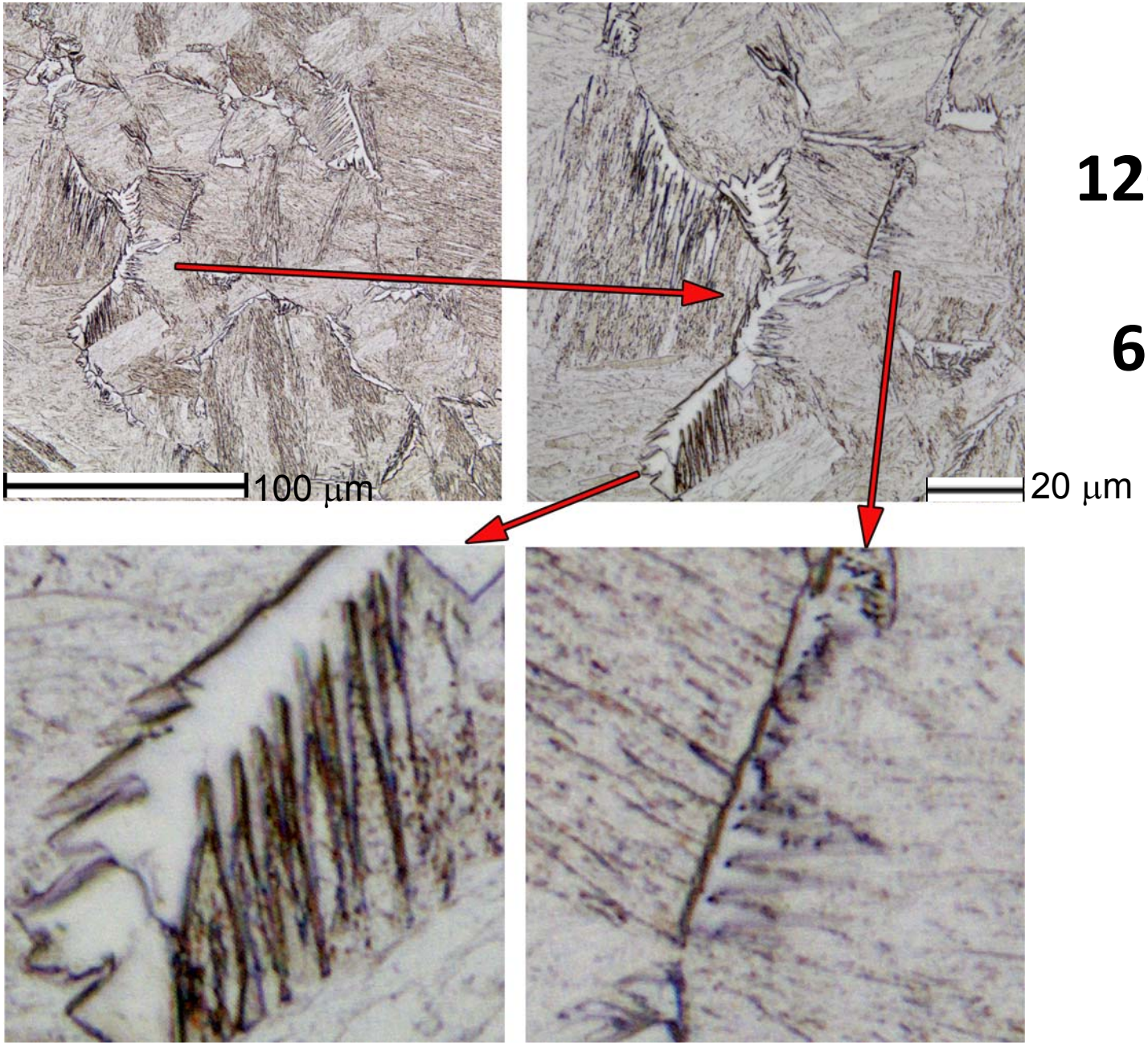


1200 °C (18 h)

→

~620 ° C (~1s)

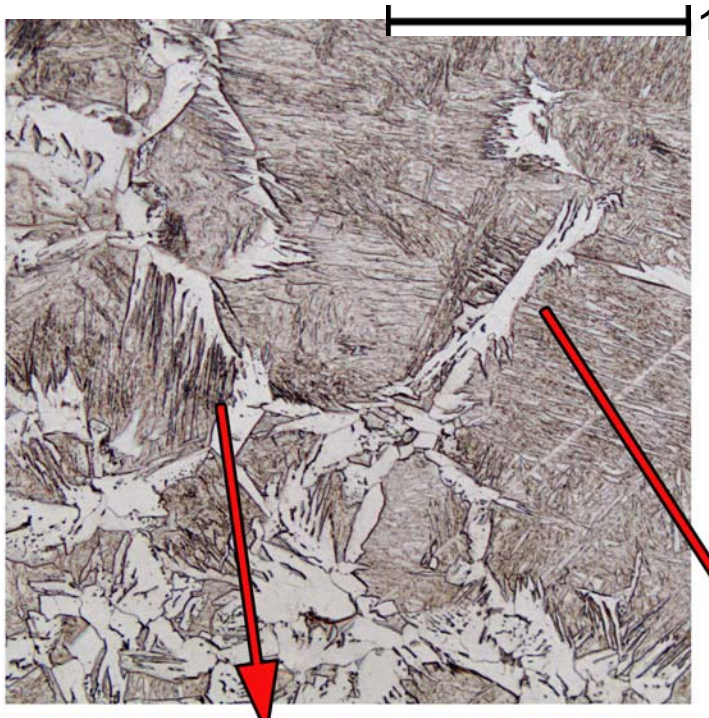
Mid-term stages of Widmanstätten ferrite growth in a fully austenitic microstructure:

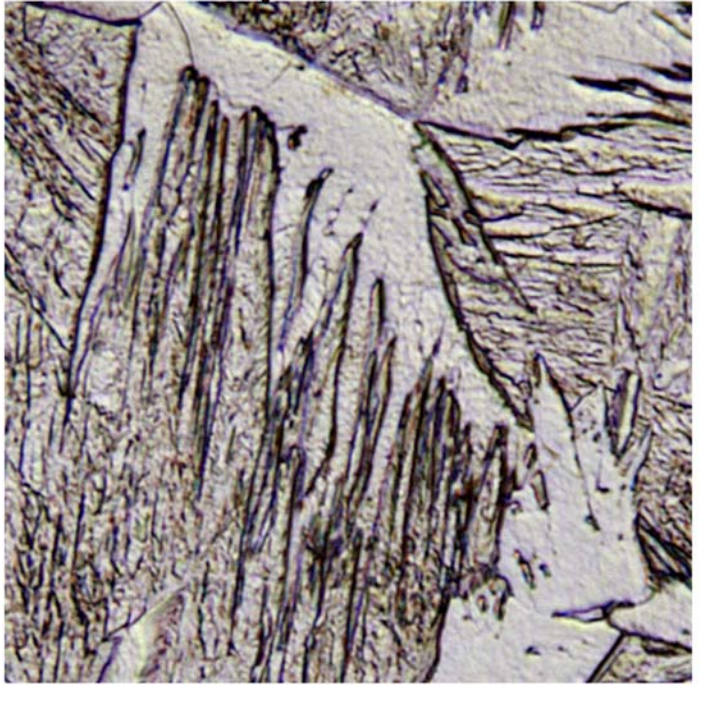


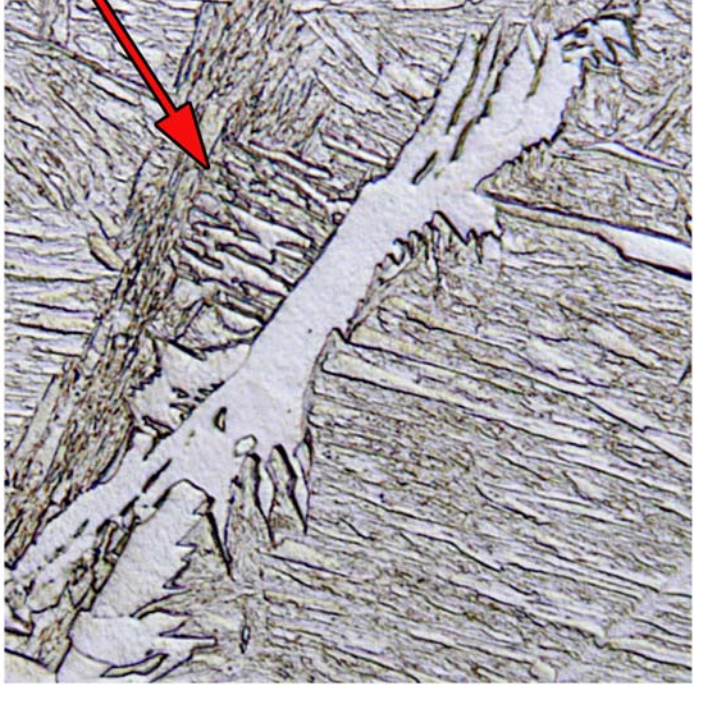
1200 °C (18 h)

→

620 ° C (~3s)





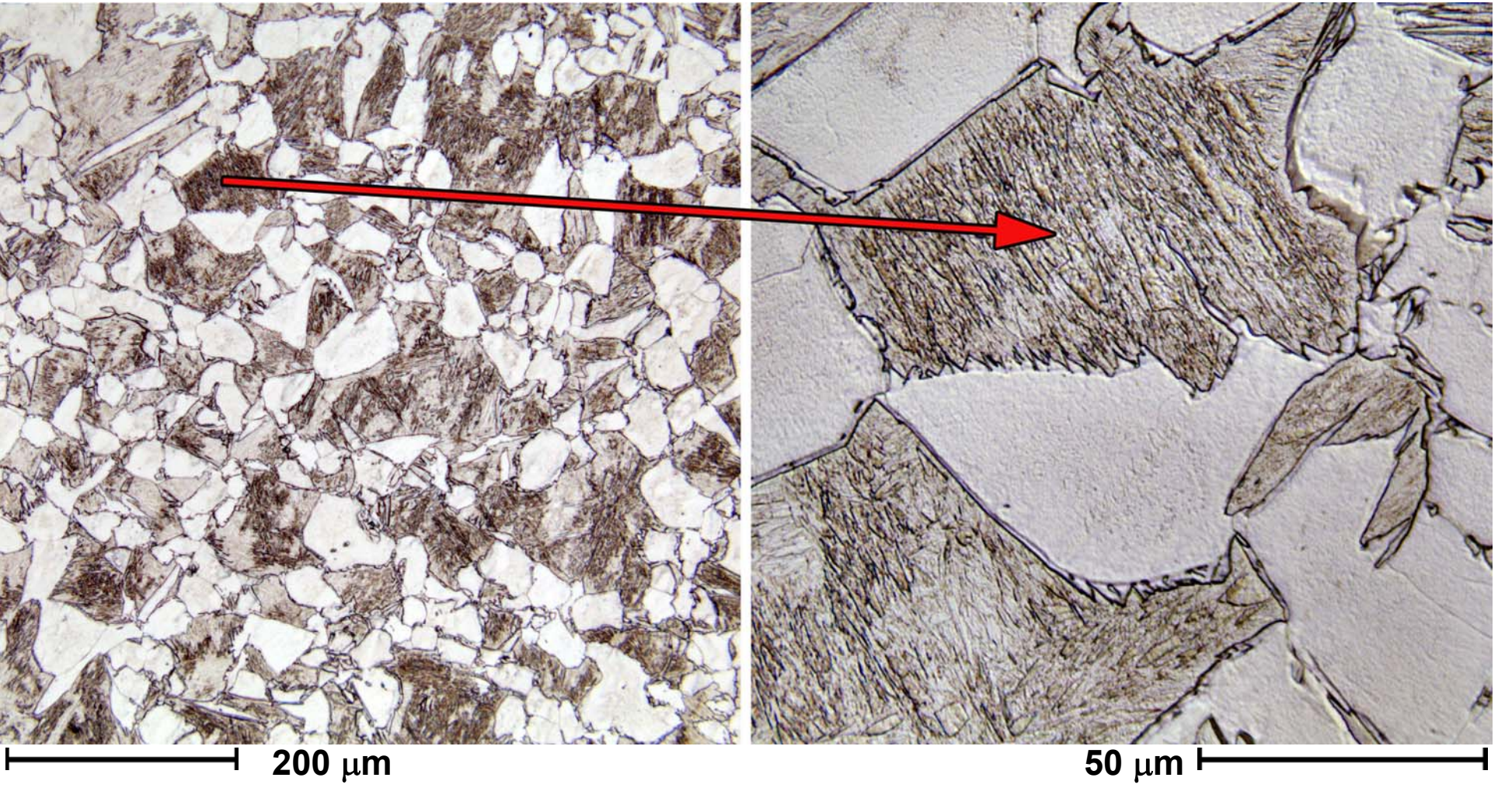


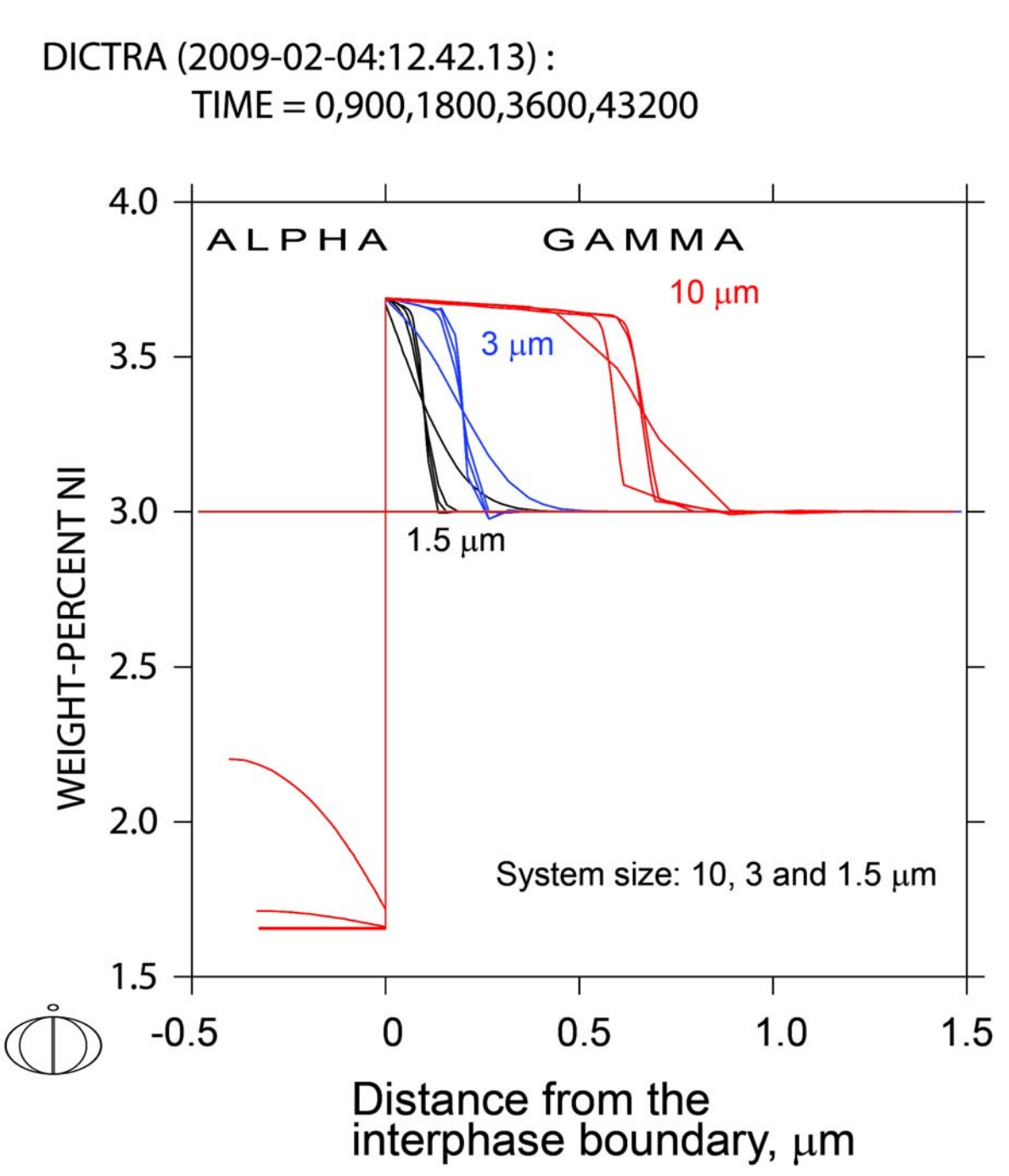
Earlier stages of Widmanstätten ferrite growth in an austenite plus allotriomorphic ferrite microstructure:

1200 °C (18 h) → 700 ° C (1h) → ~620 ° C (~1s)

Earlier stages of Widmanstätten ferrite growth in an austenite plus allotriomorphic ferrite microstructure:

1200 °C (18 h) → 700 ° C (1h)
→750 ° C (5h) → ~620 ° C (~1s)

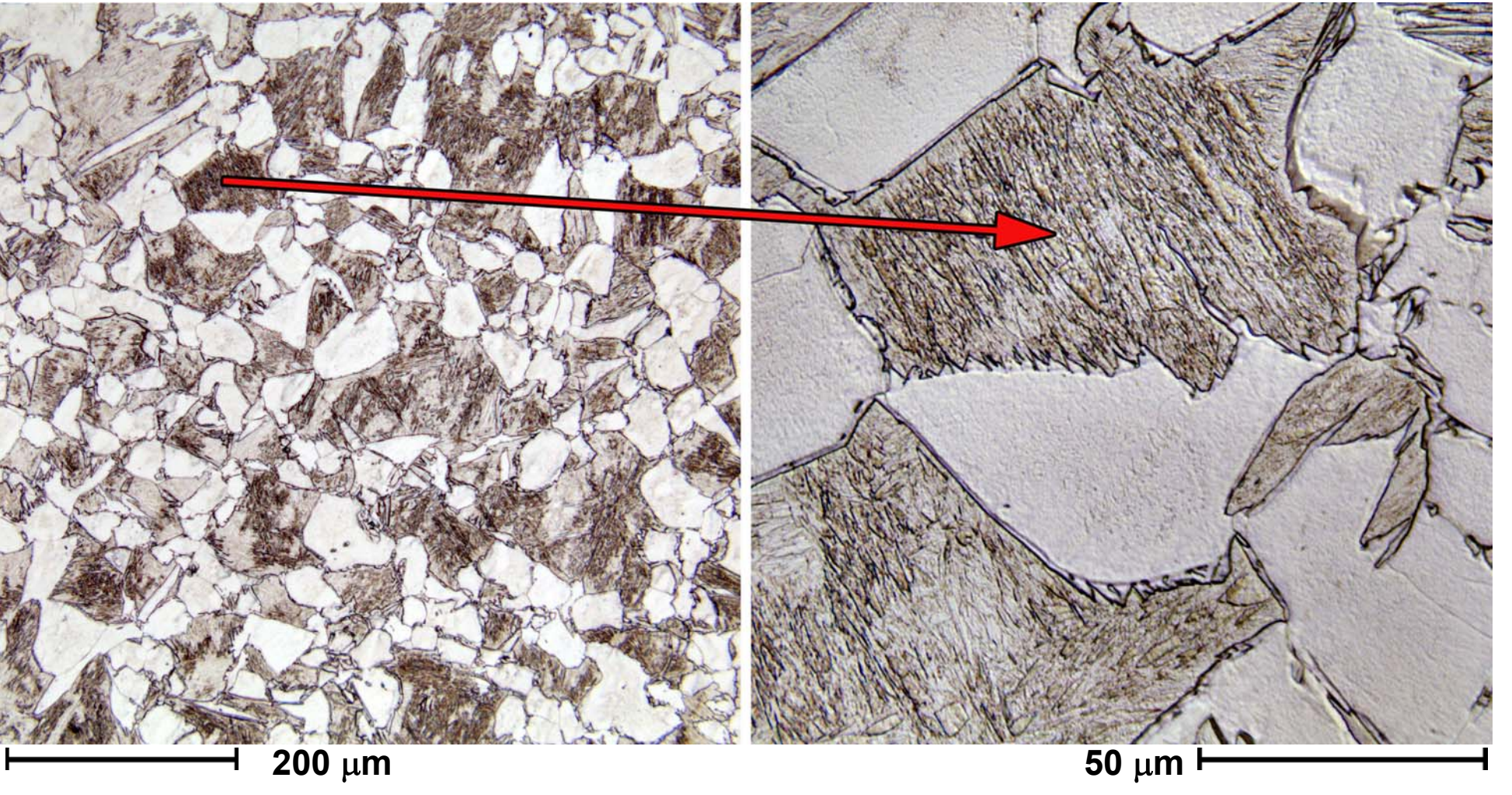


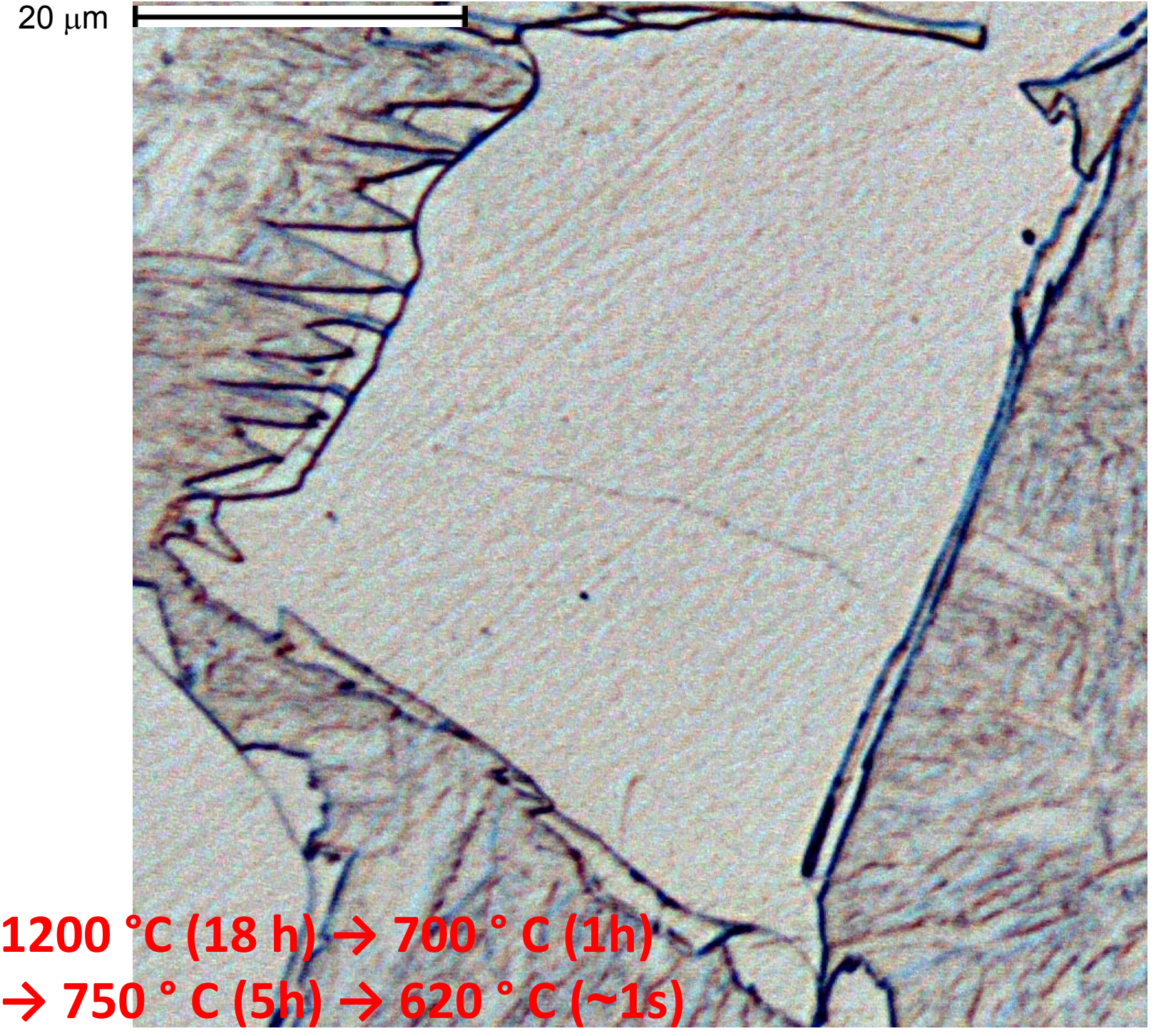


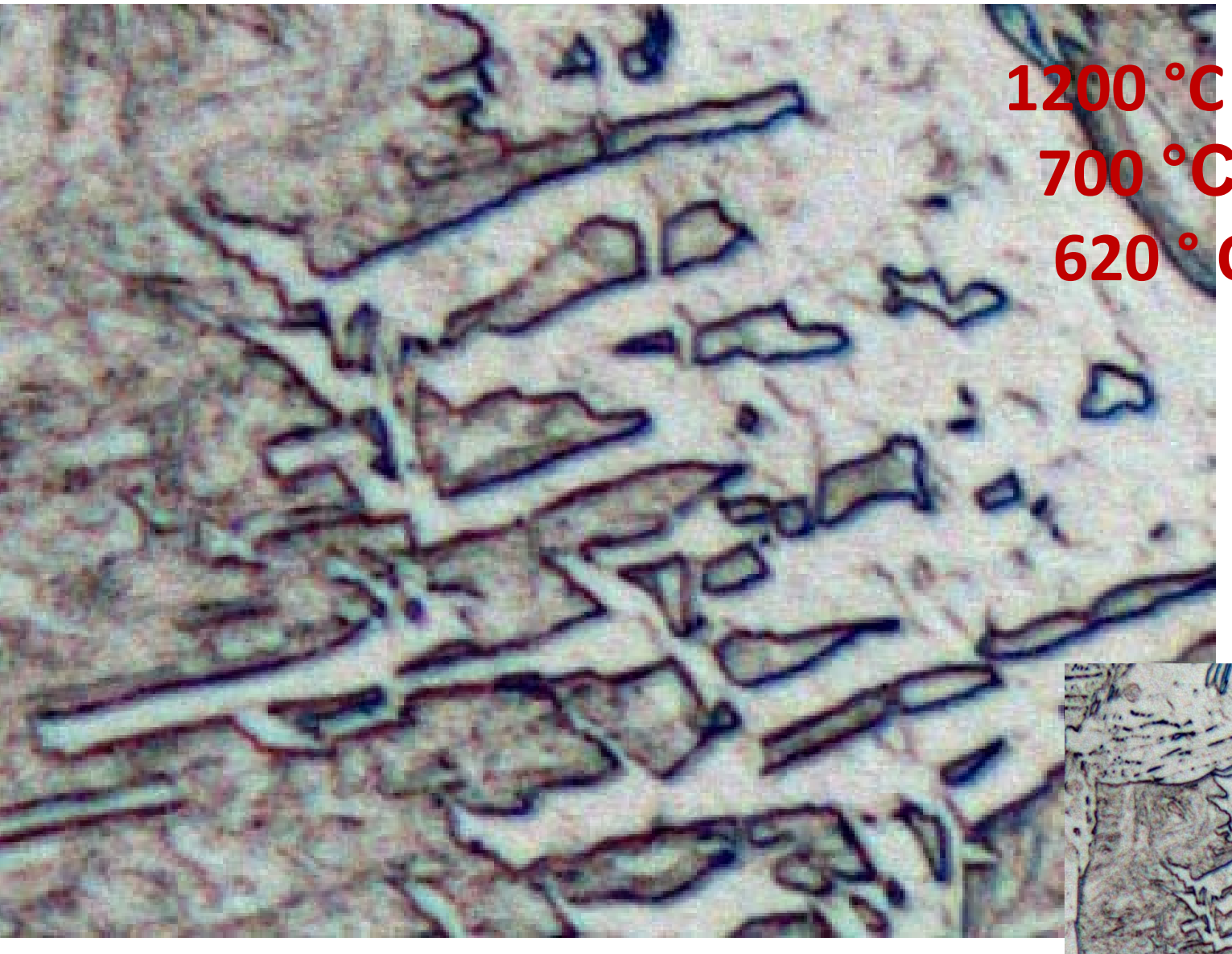
1200 °C (18 h) →
700 °C(1 h) →
750 °C (5 h)

Earlier stages of Widmanstätten ferrite growth in an austenite plus allotriomorphic ferrite microstructure:

1200 °C (18 h) → 700 ° C (1h)
→750 ° C (5h) → ~620 ° C (~1s)




20 μm
1200 °C (18 h) → 700 ° C (1h)
→ 750 ° C (5h) → 620 ° C (~1s)



1200 °C (18 h) →
700 °C (1 h) →
620 ° C (5 s)

20 μm

The on-going work allows to draw the following summary review:

(a) the very early growth of ferrite sideplates was observed mainly as sawteeth in the two type of starting microstructures;

(b) in microstructures where allotriomorphic ferrite is already present, the thesis of sympathetic nucleation of sawteeth is more consistent with the microstructures observed than that of the propagation of local instabilities;

(c) the growth of ferrite sideplates was strongly influenced by the simultaneous occurrence of grain coalescence and profuse sympathetic nucleation of new grains.

This work was supported by

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and

INPG